Association between Food Insecurity and Health-Related Quality of Life: a Nationally Representative Survey

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BACKGROUND: Food insecurity, limited or uncertain access to enough food for an active, healthy life, affected over 37 million Americans in 2018. Food insecurity is likely to be associated with worse health-related quality of life (HRQoL), but this association has not been measured with validated instruments in nationally representative samples. Given growing interest understanding food insecurity's role in health outcomes, it would be useful to learn what HRQoL measures best capture the experience of those with food insecurity.

OBJECTIVE: To determine the association between food insecurity and several validated HRQoL instruments in US adults.

DESIGN: Cross-sectional.

PARTICIPANTS: US adults (age ≥ 18), weighted to be nationally representative.

MAIN MEASURES: Food insecurity was assessed with three items derived from the USDA Household Food Security Survey Module. HRQoL was assessed using PROMIS-Preference (PROPr), which contains 7 PROMIS domains, self-rated health (SRH), Euroqol-5D-5L (EQ-5D), Health Utilities Index (HUI), and Short Form-6D (SF-6D).

KEY RESULTS: In December 2017, 4142 individuals completed at least part of the survey (31% response rate), of whom 4060 (98.0%) reported food security information. Of survey respondents, 51.7% were women, 12.5% self-identified as black, 15.8% were Hispanic, and 11.0% did not have a high school diploma. 14.1% of respondents reported food insecurity. In adjusted analyses, food insecurity was associated with worse HRQoL across all instruments and PROMIS domains ($p < .0001$ for all). The magnitude of the difference between food-insecure and food-secure participants was largest with the SF-6D, EQ-5D, and PROPr; among individual PROMIS domain scores, the largest difference was for ability to participate in social roles.

CONCLUSIONS: Food insecurity is strongly associated with worse HRQoL, with differences between food-secure and food-insecure individuals best measured using the SF-6D, EQ-5D, and PROPr. Future work should develop a specific instrument to measure changes in HRQoL in food insecurity interventions.

KEY WORDS: health-related quality of life; food insecurity; socioeconomic factors; atherosclerotic cardiovascular disease; diabetes mellitus; depression; obesity.

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Food insecurity, limited or uncertain access to enough food for an active, healthy life, affected 11.1% of American households in 2018, or over 37 million Americans.[1] Food insecurity is strongly associated with poor health, including increased prevalence of diabetes mellitus, hypertension, coronary heart disease, chronic kidney disease, and depression.[2–8] Food insecurity is also associated with more emergency department visits, more inpatient hospitalizations, and higher healthcare costs.[9–14] For these reasons, it is likely that food insecurity is associated with lower health-related quality of life (HRQoL).

Food insecurity is a key target for interventions that seek to address health-related social needs to improve health.[15–17] Common food insecurity interventions include clinic-based screening followed by referral to community food resources (e.g., food pantries), food subsidies, and medically tailored meal delivery programs.[18–25] Typically, these programs are evaluated based on their ability to improve disease-specific biomarkers (e.g., hemoglobin A1c for individuals with diabetes), or healthcare utilization (e.g., emergency department visits). However, evaluation of these interventions should include effects on patient-centered outcomes, such as HRQoL.[17] In the long-run, understanding which instruments most effectively capture any impact of food insecurity on HRQoL will

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inform the design and evaluation of food insecurity interventions.

As an initial step towards this goal, it is important to understand how different HRQoL measures are associated with food insecurity, as prior studies have not examined this association with nationally representative data across several validated instruments. Different instruments may each query different HRQoL domains. Therefore, comparing the relationship between food insecurity and HRQoL detected by each instrument will provide useful information for investigators (e.g., which instruments detect larger magnitudes of difference and have lower levels of variability). Furthermore, better understanding the variation across instruments may suggest specific pathways whereby food insecurity influences quality of life. To help fill this literature gap, we sought to determine the associations between food insecurity and several validated HRQoL instruments.

METHODS

Participants and Study Setting

Data used in this study were collected from NORC's AmeriSpeak Panel, a general population sample of non-institutionalized US adults (age ≥ 18 years) designed to represent 97% of the US population.[26] AmeriSpeak uses in-person recruitment to help overcome issues with online-only recruitment. AmeriSpeak participants were invited using sampling strata based on age, race/Hispanic ethnicity, education, and gender. This survey was offered in English and Spanish, and participants could choose to complete it either online or by telephone. NORC provided demographic information about the sample and the sampling weights necessary to make nationally representative estimates, accounting for non-response. IRB approval was obtained from the University of Pittsburgh.

Food Insecurity

Food insecurity was assessed based on responses to three food insecurity items derived from the USDA Household Food Security Survey Module.[27] The items used asked how often, in the last 12 months, the respondent or people in the respondent's household (1) worried whether your food would run out before you had money to buy more; (2) the food that you bought did not last, and you didn't have enough money to get more; or (3) you couldn't afford to eat balanced meals. Response options were "Always," "Usually," "Sometimes," "Rarely," and "Never." Participants who responded "Always" or "Usually" to any of these questions were categorized as food insecure, with the remainder of respondents being categorized as food secure.

Health-Related Quality of Life Measures

We used several previously validated patient-reported HRQoL measures. Our goal was to assess the relationship between food insecurity and a wide variety of instruments in order to capture subtleties in the relationship between food insecurity and specific instruments that measure HRQoL.

PROMIS Domains

This study measured 7 adult PROMIS domains[28]: Cognitive Function v2.0, Depression v1.0, Fatigue v1.0, Pain Interference v1.0, Physical Function v2.0, Sleep Disturbance v2.0, and Ability to Participate in Social Roles and Activities v2.0. The PROMIS questions refer to the respondent's own health "in the past 7 days" and have 5 response options. This study collected 2 questions per PROMIS domain and responses were scored for each individual domain using the Assessment Center Scoring Service with default settings. PROMIS domains are constructed such that the US population mean is 50 with a standard deviation of 10. Higher scores indicate more of the construct; higher scores on function scales indicate more function (i.e., better cognitive function, physical function, and social roles) while higher scores on symptom scales indicate more of a symptom (i.e., worse depression, fatigue, pain interference, sleep disturbance).

PROMIS-Preference

PROMIS-Preference (PROPr) is based on levels of functioning for the 7 PROMIS domains collected in this study. The PROPr scoring algorithm was developed from standard gamble valuations in a US sample. Each domain was described using 2 items to create a unidimensional valuation (e.g., values over a range of depression). The 7 domains were then combined using multi-attribute utility theory to give a single score that represents average health preferences in the USA.[29–31] Possible PROPr scores range from − .022 (worst) to 1.0 (best).

Self-Rated Health

The self-rated health (SRH) item was, "In general, my health is: excellent, very good, good, fair, poor."[32]

Euroqol-5D-5L

Euroqol-5D-5L (EQ-5D) descriptive system has 5 domains (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) and this study used the EQ-5D-5L version with 5 response options per domain.[33] The EQ-5D-5L questions refer to "your health today." We scored the EQ-5D-5L using the time trade-off value set from US adults.[34] Possible scores range from − .699 (worst) to 1.0 (best).

Short Form-6D

The Short Form-6D (SF-6D) scoring algorithm uses 7 questions from the Short Form-12 (SF-12) that were evaluated using the standard gamble technique in a representative sample of the UK population.[35] Six questions reference "the last 4

weeks" and cover 5 domains (role limitations, pain, vitality, social functioning, and mental health) and 1 question references a "typical day" to cover physical function. Possible SF-6D scores range from .345 (worst) to 1.0 (best).

Health Utilities Index

The self-administered Health Utilities Index (HUI) questionnaire allows scoring of both Mark 2 and Mark 3.[36,37] The HUI Mark 2 defines health status on 6 attributes (sensation, mobility, emotion, cognition, self-care, and pain). The HUI Mark 3 defines health on 8 attributes (vision, hearing, speech, ambulation, dexterity, emotion, cognition, and pain). HUI questions refer to "your level of ability or disability during the past week." Scoring algorithms for both HUI Mark 2 and HUI Mark 3 were derived from standard gamble assessments made by adults in community samples in Hamilton, Ontario. HUI Mark 2 scores range from − .03 (worst) to 1.0 (best); HUI Mark 3 scores range from − .36 (worst) to 1.0 (best).

All respondents were asked PROMIS and SRH questions. Respondents were randomly assigned to receive either the EQ-5D-5L and SF-12 or the HUI, to reduce respondent burden and repetitive questions. The minimally important difference for the EQ-5D-5L, SF-12, HUI, or PROPr is generally between .03 and .05.[38] We refer to scores on EQ-5D-5L, SF-12, HUI, PROPr, and SRH as "summary scores" and scores on individual PROMIS domains as "domain scores." All HRQoL measures included domains of physical function, pain, and mood. However, each has a different emphasis beyond this common basis. For example, HUI does not include questions about usual activities or role activities, but does include cognitive function. The EQ-5D and SF-6D include questions about activities and roles but do not include questions about cognitive function. If a key mechanism by which food insecurity influences HRQoL is cognitive function, we would expect the HUI instruments and PROPr to detect greater differences than EQ-5D and SF-6D. Conversely, if a key mechanism is social roles and activities, we would expect the EQ-5D, SF-6D, and PROPr to detect greater differences than HUI.

Covariates and Other Data

We collected information on several factors that may confound the relationship between food insecurity and HRQoL. These were age (categorized as 18–24, 25–34, 35–44, 45–54, 55–64, 65–74, 75+), gender, race (categorized as white only, black only, other), ethnicity (categorized as Hispanic versus non-Hispanic), household income (categorized as < $20,000, $20,000 to $40,000, $40,000 to $60,000, $60,000 to $100,000, > $100,000), educational attainment (categorized as no high school diploma, high school graduate or equivalent, some college, bachelors or above), health insurance (categorized as uninsured or single service, private, Medicare, Medicaid/CHIP/State plan, other government), whether the participant lived alone, and region of residence (categorized as New England, Mid-Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, Pacific).

In order to assess relationships between food insecurity and HRQoL in specific clinical populations, we also assessed subgroups that self-reported: atherosclerotic cardiovascular disease, depression, diabetes mellitus, overweight (body mass index [BMI] 25 to 30 kg/m^2), and obesity (BMI > 30 kg/m^2).

Statistical Analyses

We first conducted descriptive statistics. We then fit a series of regression models with a goal of determining the association between food insecurity and HRQoL measures. For ease of coefficient interpretability, we fit linear models (except for self-reported health status, where we fit a cumulative logistic model), adjusting for age, gender, race/ethnicity, income, education, health insurance, whether the participant lived alone, and region of residence. We chose not to adjust for chronic conditions (e.g., diabetes) because of the association between food insecurity and these conditions[2,4,8], which suggests that chronic conditions may be mediators of the relationship, if any, between food insecurity and HRQoL. Instead, we fit similar models in subsamples stratified by self-report of atherosclerotic cardiovascular disease, depression, diabetes mellitus, overweight, and obesity. Participants who reported more than one condition were included in analyses for each of the conditions they reported. To determine whether food insecurity was associated with differences in outcomes, compared with those who were food secure, we conducted F-tests on the model regression coefficient contrasting food-secure and food-insecure status, and constructed 95% confidence intervals. To compare the magnitude of the association between food insecurity and a given HRQoL score across all the HRQoL instruments used in the study, which have different scales, we calculated partial omega-square statistics.[39,40] These effectively standardize the scores, and can be interpreted as the amount of variation in the outcome explained by food insecurity, after accounting for the variation explained by other variables in the model. Omega-square statistics range from 0 to 1, with greater statistics indicating that more variation in the outcome is explained by food security status. Thus, a greater omega-square statistic suggests that a given instrument may be better attuned to the ways in which food security status is related to HRQoL.

All analyses were conducted in SAS version 9.4 (Cary, NC), and analyses included sampling weights so that estimates would reflect a nationally representative sample. The sampling design is not stratified, so clustering adjustment for standard errors is not needed. A p value < .05 indicated statistical significance. The analysis testing the relationship between food insecurity and the PROPr score was considered the primary analysis for this study, with additional analyses considered exploratory.

RESULTS

In December 2017, 13371 individuals were invited from the panel and 4142 individuals completed at least part of the survey (31%), of whom 4060 (98.0%) reported food security information (survey weights accounted for non-response). Of survey respondents, 51.7% were women, 12.5% self-identified as black, 15.8% were Hispanic, and 11.0% did not have a high school diploma. Additional demographic information is presented in Table 1. 14.1% of respondents reported food insecurity. Those who were food insecure, compared with food secure, were younger ($p < .0001$), more likely to be racial/ethnic minorities ($p < .0001$) and had lower income ($p < .0001$).

In unadjusted analyses (Table 2), food insecurity was associated with worse self-reported health status ($p < .0001$), lower HRQoL for all summary scores ($p < .0001$ for all), and worse symptomatology and decreased function for all PROMIS domains ($p < .0001$ for all).

In analyses adjusted for age, gender, race/ethnicity, income, education, health insurance, whether the participant lived alone, and region of residence, food insecurity remained associated with lower HRQoL summary scores across all summary scores ($p < .0001$ for all) and worse PROMIS scores across all domains ($p < .0001$ for all) (Table 3). Adjusted differences ranged from − .11 to − .21 across summary scores.

Food insecurity typically accounted for approximately 4 to

Table 1 Participant Characteristics by Food Security Status, Unweighted *n* and Weighted %

N	All		Food secure		Food insecure		*p*
	4142	Weighted %	3532	Weighted %	582	Weighted %	
	N		*N*		*N*		
Age categories							
18–24	291	11.8	230	10.9	61	17.2	< .0001
25–34	915	18.6	746	17.5	169	25.4	
35–44	731	15.9	600	15.3	131	19.6	
45–54	664	16.0	549	15.4	115	19.8	
55–64	712	17.7	647	18.7	65	11.5	
65–74	549	13.8	513	15.2	36	5.4	
75+	252	6.2	247	7.1	5	.8	
Women	2237	51.7	1888	51.5	349	53.5	.49
Race							
White	3016	72.4	1669	74.5	347	59.9	< .0001
Black	467	12.5	370	11.7	97	17.6	
Other	631	15.1	493	13.8	138	22.5	
Hispanic ethnicity	632	15.8	484	14.4	148	23.5	< .0001
Education							
No high school diploma	253	11.0	182	9.3	71	21.4	< .0001
High school graduate or equivalent	801	28.9	646	27.8	155	35.7	
Some college	1745	28.5	1471	28.3	274	29.6	
Bachelors or above	1315	31.6	1233	34.6	82	13.3	
Household income							
> $100,000	761	20.8	729	23.0	32	7.4	< .0001
$60,000 to $100,000	943	22.5	867	24.2	76	12.6	
$40,000 to $60,000	785	17.7	695	18.2	14.3	16.8	
$20,000 to $40,000	939	22.1	746	20.3	193	33.1	
< $20,000	686	16.9	495	14.2	191	32.6	
Insurance							
Uninsured or single service	503	13.8	376	12.1	127	23.9	< .0001
Private	2233	52.2	2054	56.1	179	29.1	
Medicare	737	18.8	606	17.8	131	24.2	
Medicaid/CHIP/State plan	400	9.8	285	8.4	115	18.4	
Other government	202	5.4	178	5.6	24	4.6	
Lives alone	1834	45.0	1517	43.4	317	54.4	< .0001
Region of residence							
New England	179	4.7	147	4.5	32	5.8	.072
Mid-Atlantic	590	13.1	438	13.3	71	11.8	
East North Central	786	14.4	700	15.1	86	10.3	
West North Central	392	6.4	346	6.5	46	6.1	
South Atlantic	540	20.0	466	20.1	74	19.3	
East South Central	222	5.9	186	5.4	36	8.9	
West South Central	326	11.8	277	11.9	49	11.1	
Mountain	412	7.3	344	7.1	68	8.4	
Pacific	748	16.4	628	16.0	120	18.3	

p values from chi-square tests
N = actual number of respondents. % = percentage weighted to be nationally representative. For that reason, % cannot be directly calculated from N

Table 2 Unadjusted Outcome Scale Scores, Weighted to be Nationally Representative

Summary scores					
Scale	***N***	**Whole sample**	**Food secure**	**Food insecure**	***p* value**
Self-rated health status	4112	*N* (Weighted %)	*N* (Weighted %)	*N* (Weighted %)	
Excellent		475 (12.42)	428 (12.77)	47 (10.35)	< .001
Very good		1533 (37.55)	1397 (40.06)	136 (22.55)	
Good		1498 (34.82)	1278 (34.66)	220 (35.80)	
Fair		497 (12.62)	362 (10.69)	135 (24.16)	
Poor		109 (2.59)	65 (1.83)	44 (7.15)	
	N	Mean (SD)	Mean (SD)	Mean (SD)	
SF-6D	2014	.77 (.14)	.79 (.13)	.65 (.14)	< .0001
EQ-5D (5-level US scoring)	2033	.79 (.25)	.83 (.21)	.59 (.36)	< .0001
HUI 2	2040	.82 (.18)	.83 (.16)	.70 (.24)	< .0001
HUI 3	2039	.74 (.27)	.77 (.24)	.55 (.36)	< .0001
PROPr	4114	.49 (.22)	.52 (.20)	.31 (.20)	< .0001
PROMIS domain scores					
Scale		Whole sample Mean (SD)	Food secure Mean (SD)	Food insecure Mean (SD)	*p* value
Cognitive function	4130	52.88 (7.79)	53.79 (7.35)	47.42 (8.12)	< .0001
Depression	4132	52.72 (8.22)	51.86 (7.87)	57.93 (8.44)	< .0001
Fatigue	4131	51.34 (8.17)	50.45 (7.73)	56.68 (8.73)	< .0001
Pain inference	4133	51.65 (8.60)	50.63 (7.96)	57.73 (9.78)	< .0001
Physical function	4134	50.85 (8.85)	51.67 (8.53)	46.12 (9.17)	< .0001
Sleep disturbance	4127	49.45 (7.13)	48.81 (6.95)	53.24 (6.97)	< .0001
Social roles	4127	53.60 (8.37)	54.67 (7.74)	47.25 (9.11)	< .0001

p value is comparing outcome scores for a food-insecure, compared with food-secure, individual. T tests were used for all comparisons except self-rated health status which used a Wilcoxon test. Short Form-6D (SF-6D): Possible scores range from .345 (worst) to 1.0 (best). Euroqol-5D (EQ-5D), 5 level scoring: Possible scores range from − .699 (worst) to 1.0 (best). Health Utilities Index (HUI): Mark 2 scores range from − .03 (worst) to 1.0 (best); HUI Mark 3 scores range from − .36 (worst) to 1.0 (best). PROMIS-Preference (PROPr): Possible PROPr scores range from − .022 (worst) to 1.0 (best). PROMIS domains are constructed such that the US population mean is 50 with a standard deviation of 10. Higher scores indicate more of the construct; higher scores on function scales indicate more function (i.e., better cognitive function, physical function, and social roles) while higher scores on symptom scales indicate more of a symptom (i.e., worse depression, fatigue, pain interference, sleep disturbance). All respondents were asked PROMIS and SRH questions. Respondents were randomly assigned to receive either the EuroQol-5D-5L and SF-6D or the Health Utilities Index, to reduce respondent burden and repetitive questions

9% of the variation in scores across HRQoL instruments, adjusted for the other covariates. The magnitude of the difference between food-insecure and food-secure participants was largest with the SF-6D instrument (partial omega-square .091, 95% CI .069 to .116; Fig. 1), but the partial omega-square for the EQ-5D and PROPr fell within this confidence interval. With regard to PROMIS domain scores, the magnitude of the difference between food-insecure and food-secure participants was greatest for ability to participate in social roles (partial omega-square .067, 95% CI .053 to .082; Fig. 2). Food insecurity consistently accounted for a large share of the variation in HRQoL, relative to other covariates (eTable 1).

Patterns seen in the overall sample typically held when examining subgroups with specific chronic conditions—HRQoL summary scores and PROMIS domain scores were statistically significantly worse for those experiencing food insecurity in all cases but one (EQ-5D score in those with diabetes, where the point estimate was worse but the difference was not statistically significant) (eTables 2–6).

DISCUSSION

In this nationally representative sample, food insecurity was strongly associated with worse HRQoL summary scores and PROMIS domain scores. The SF-6D, EQ-5D, and PROPr seemed particularly attuned to detecting differences in HRQoL by food security status. PROPr has the added benefit of also providing PROMIS domain scores. The relationship between HRQoL and food insecurity within subgroups defined by comorbidities was similar to that seen in the overall sample.

The differences in scores associated with food insecurity are both statistically significant and large. The minimally important difference of health utility summary scores is generally between .03 and .05[38]; differences associated with food insecurity were .11 to .21. For context, in other US nationally representative studies using the same scores, differences associated with diabetes were .04 to .09, differences associated with COPD were .11 to .22, and differences associated with angina were .07 to .16.[41] Likewise, the minimally important difference of PROMIS domain scores is generally between 3 and 5; the smallest difference in these analyses was 3.8 (sleep disturbance) and the largest was 6.3 (social roles).

The findings of this study are consistent with and extend those of prior studies that typically found food insecurity is associated with lower HRQoL.[42–46] However, these studies were not nationally representative, focused on specific subsets

Table 3 Adjusted Associations between Food Insecurity and Outcome Scales

Scale	Beta coefficient	SE	*p* value	Omega	95% CI limits	
SF-6D	**− .1202**	**.0085**	**< .0001**	**.0911**	**.0690**	**.1161**
EQ-5D (5-level US scoring)	− .2083	.0153	< .0001	.0844	.0632	.1087
HUI 2	− .1106	.0121	< .0001	.0397	.0251	.0582
HUI 3	− .1700	.0177	< .0001	.0436	.0282	.0628
PROPr	− .1720	.0094	< .0001	.0765	.0618	.0927
	Odds ratio**	95% CI	*p* value	Omega	95% CI limits	
Self-rated health status	.513	.401–.656	< .0001	–	–	–
PROMIS domain scores						
Domain	Beta coefficient	SE	*p* value	Omega	95% CI limits	
Cognitive function	− 4.5908	.3460	< .0001	.0412	.0303	.0540
Depression	4.6815	.3700	< .0001	.0375	.0272	.0499
Fatigue	4.9354	.3621	< .0001	.0434	.0323	.0565
Pain inference	5.7726	.3792	< .0001	.0536	.0412	.0678
Physical function	− 5.0911	.3676	< .0001	.0448	.0334	.0580
Sleep disturbance	3.7574	.3260	< .0001	.0314	.0219	.0429
Social roles	− 6.3527	.3723	< .0001	.0666	.0529	.0820

Models adjusted for age, gender, race/ethnicity, income, education, health insurance, whether the participant lived alone, and region of residence
***Results for self-rated health status from a cumulative logistic model. Thus, the reported odds ratio compares the odds that a response for a food-insecure individual is likely to be in a better category than for a food-insecure individual. An odds ratio less than 1 indicates that those who are food insecure are less likely to report a better health status than a food-secure respondent, adjusted for the covariates in the model*
Short Form-6D (SF-6D): Possible scores range from .345 (worst) to 1.0 (best). Euroqol-5D (EQ-5D), 5 level scoring: Possible scores range from − .699 (worst) to 1.0 (best). Health Utilities Index (HUI): Mark 2 scores range from − .03 (worst) to 1.0 (best); HUI Mark 3 scores range from − .36 (worst) to 1.0 (best). PROMIS-Preference (PROPr): Possible PROPr scores range from − .022 (worst) to 1.0 (best). PROMIS domains are constructed such that the US population mean is 50 with a standard deviation of 10. Higher scores indicate more of the construct; higher scores on function scales indicate more function (i.e., better cognitive function, physical function, and social roles) while higher scores on symptom scales indicate more of a symptom (i.e., worse depression, fatigue, pain interference, sleep disturbance)

of the population, and/or used only a single HRQoL instrument—often the "Healthy Days" tool.[47] This study adds nationally representative data with a variety of validated, and commonly used, HRQoL instruments. Despite widespread use, neither "Healthy Days" nor single item self-rated health has an established minimally important difference. The difficulty comparing "Healthy Days" and single item self-rated health to other HRQoL scores, along with difficulty in establishing a meaningful change, illustrates limitations of using these as outcomes.

As clinical and public health evaluations shift their focus to person-centered outcomes, the use of linear, validated, preference-based summary scores of HRQoL has advantages for both modeling flexibility and interpretability. First, they provide a single score that combines multiple health domains. This provides a standardized way to compare interventions with effects on different domains of health (e.g., comparing one intervention that improves depression to another intervention that improves pain) or with differential effects on different domains of health (e.g., comparing one intervention that moderately improves depressive symptoms but mildly worsens physical functioning to another intervention that mildly improves depression with no change in physical functioning). Second, generic, societal preference-based scores are appropriate for use in cost-effectiveness analyses. Third, their widespread use facilitates comparison across different types of interventions. Of this group, PROPr is unique because it is constructed from PROMIS domains. This means that in addition to having a summary score, investigators can explore the effects of interventions on individual domains, acknowledging that societal weights do not necessarily represent individual weights.

Prior qualitative studies have suggested that food insecurity affects many aspects of individuals' lives, even ones that may not seem directly related to food or diet.[48,49] Examples of this include individuals reporting that fulfilling social roles can be difficult when worrying about food.[48,49] This study helps quantify some of those associations. For example, we found a strong association between food insecurity and the social role domain within PROPr. Furthermore, we found that HRQoL scales, like PROPr and SF-6D, that query aspects of social roles detected differences in HRQoL with larger point estimates than scales that did not, like HUI.

This study has implications for future work on the relationship between food insecurity and HRQoL. Through mechanisms such as PROMIS, there are now a wide variety of health domains available for use. PROPr uses 7 domains, but there are presently 96 PROMIS domains for adults and 19 for children ages 5–17.[50] Future work could determine whether other domains are more attuned to the circumstances faced by those who experience food insecurity than domains used here. Additionally, this study demonstrates inter-individual differences related to food insecurity, but does not address which instrument will be most sensitive to the effects of changing food insecurity (intra-individual change). Such work could aid in the development of a "condition-specific" outcome measure for food insecurity interventions that may comprised available PROMIS domains with or without supplemental questions. Additionally, analyses in other clinical populations,

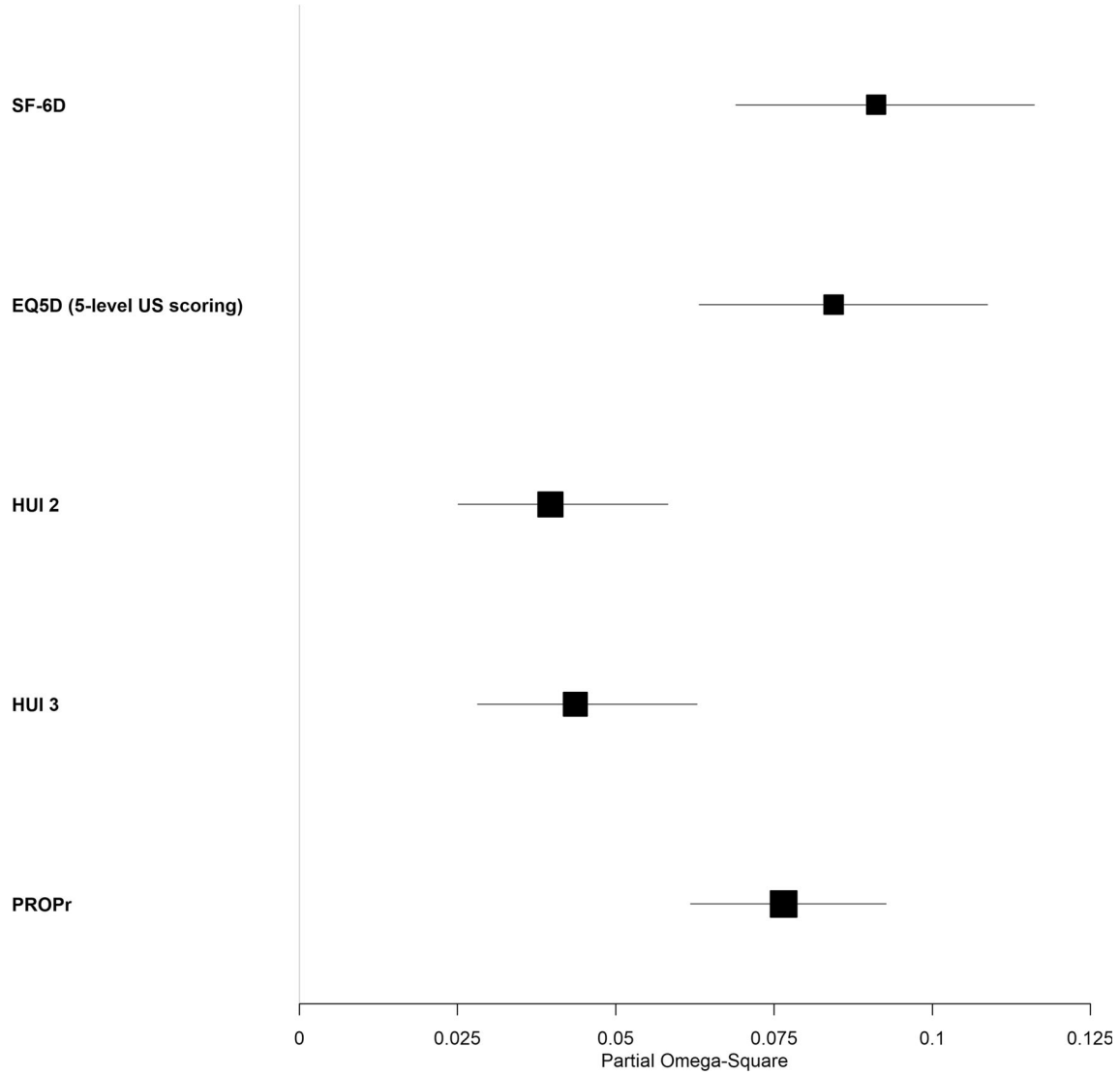

Figure 1 Forest plot comparison of partial omega-square statistics across summary scores.

particularly those that include diet as part of condition management, such as chronic kidney disease, should be pursued.

This study should be interpreted in light of several limitations. Though food security questions were derived from USDA Food Security Survey Module, the response options were modified to fit the survey formatting. However, food insecurity prevalence estimated from this study is very similar to the national average reported by the USDA in December 2017 (the study period)[1], suggesting that this change did not meaningfully impact food security assessment. The data were cross-sectional, so we cannot determine whether food insecurity caused lower HRQoL, or vice versa. Though we used several common HRQoL instruments, there are of course other HRQoL instruments that were not included. Finally, online panel surveys can be biased with regard to which individuals participate, and we did not have access to data comparing the characteristics of those who did versus did not participate. However, this particular panel uses face-to-face recruitment to help mitigate this concern, and weighting to help account for non-response bias.

In this study using responses from a nationally representative panel of adults, food insecurity was strongly associated

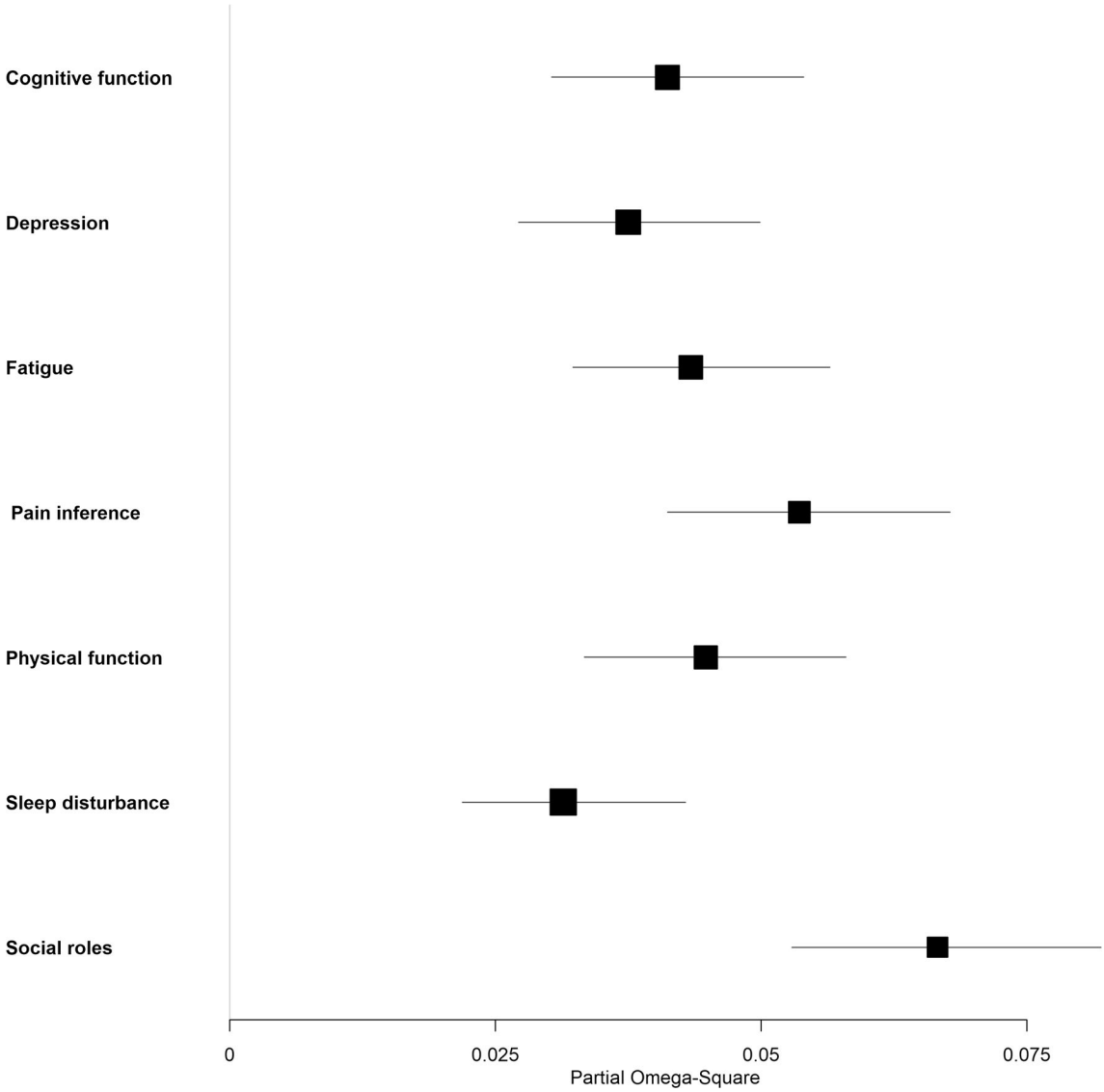

Figure 2 Forest plot comparison of partial omega-square statistics across PROMIS domains.

with worse HRQoL, both in the overall sample and in subgroups defined by specific comorbidities. Of HRQoL instruments, the SF-6D, EQ-5D, and PROPr were particularly attuned to the specific challenges of those experiencing food insecurity. Improving our ability to measure HRQoL in those who experience food insecurity will enable us to better develop and study interventions that address this important health risk.

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Compliance with Ethical Standards:

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